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VASCULAR FLORA AND ECOLOGICAL SURVEY OF AN OLD-GROWTH FOREST REMNANT IN THE OZARK HILLS OF SOUTHERN ILLINOIS

Mark A. Basinger & Philip Robertson

Department of Plant Biology, Southern Illinois University, Carbondale, Illinois 62901-6509 U.S.A.

ABSTRACT

The vascular flora of Weaver's Woods, a 7.2 ha old-growth forest remnant, was studied during the 1995 growing season. A total of 215 species and subspecific taxa in 77 families and 155 genera were identified, of which 24 (11.2%) were non-native to the site. The predominant photosynthetic pathway was C_3 (96.3%), and only eight taxa possessed the C_4 pathway. The dominant growth form was perennial (78.0%), with most taxa being woody or herbaceous. The most common lifeforms were hemicryptophytes (76 taxa/35.3%) and phanaerophytes (62 taxa/28.8%). Four habitats were identified, with species richness being highest in dry-mesic upland forest and lowest in forest edge. Non-native taxa were most common along intermittent streams in mesic upland forest and along the forest edge. Abundance ratings confirmed that most taxa (80.9%) were infrequently encountered, which may be related to an increase in mesophytic species (increased shade) and limited habitat for shade intolerant plant species.

KEY WORDS: Illinois, floristics, life-forms, photosynthetic pathways

INTRODUCTION

Old-growth mesic upland forests are rare in the central hardwood region (Parker 1989). It is estimated that less than 1% of the original forest in this region remains as old-growth, and the majority of these forests are small (< 15 ha), isolated, and within fragmented landscapes (Parker, *et al.* 1985; Parker 1989). It is well-documented that upland forests dominated by oak-hickory are declining in the region from poor regeneration and are being replaced by *Acer saccharum* Marsh. and *Fagus grandifolia* Ehrh. (Boggess & Bailey 1964; Weaver & Ashby 1971; Schmelz, *et al.* 1974; Barton & Schmelz 1987; Shotola, *et al.* 1992; Franklin, *et al.* 1993). The decline of oak-hickory forests is thought to be caused by a combination of climatic change and removal of anthropogenic and natural disturbances (Parker 1989).

Weaver's Woods, one of the best documented old-growth forests in the Midwest, provides an excellent opportunity to add to our knowledge of the old-growth condition (Weaver & Ashby 1971; Shotola, *et al.* 1992). An extensive data set on woody and herbaceous vegetation at Weaver's Woods has been accumulated since 1956, but no one has undertaken a study of the complete vascular flora. Therefore, the objectives of this study were, following guidelines in Palmer, *et al.* (1995), to survey the vascular flora of Weaver's Woods, delineate habitat types, and describe the flora in terms of growth forms, life forms, and photosynthetic pathways.

STUDY AREA

Weaver's Woods is a privately owned 7.2 ha forest located approximately 8 km south of Jonesboro, Illinois (Figure 1). The study site is located within the Southern Section of the Ozark Division, a driftless region of dissected topography that is the eastern extent of the Salem Plateau (Schwegman, *et al.* 1973). Braun (1950) included the Illinois Ozarks as part of the Hill Section of the Western Mesophytic Forest. Moist ravines and sheltered slopes are favorable for mixed mesophytic vegetation, while oak-hickory forests develop on drier uplands (Braun 1950).

Climate in southern Illinois is continental with warm summers and mild winters. Thornthwaite (1948) considered the climate to be humid mesothermal with little to no water deficit in any season and a potential annual evapotranspiration of 76.2 cm. Average yearly precipitation at Anna, approximately 9 km north of the study site, is 117 cm. Precipitation is evenly distributed throughout the year, though extended periods of drought can occur during the summer months. The mean January temperature is 2°C while the mean July temperature is 26°C at Anna. The average number of frost-free days is 206, extending from 7 April to 30 October (Miles, *et al.* 1979).

Upland soils at Weaver's Woods consist primarily of Alford silt loam, approximately 81% of the study area. Alford silt loam is a well-drained, high available water-holding capacity typic hapludalf formed from deep loessal deposits. Other upland soils of minor importance comprise approximately 5% of the study area and are found on the steepest slopes. Ravine bottoms comprise approximately 15% of the study area and are composed of Elsah cherty silt loam and Haymond silt loam (typic udifluvents), which are moderately to well-drained soils (Weaver & Ashby 1971; Miles, *et al.* 1979; Shotola, *et al.* 1992).

Weaver's Woods, owned by the Weaver family since the 1820's, has remained free from fire and grazing for over 100 years (Weaver & Ashby 1971; Shotola, *et al.* 1992). Selective tree removal occurred between 1871 and 1950, with approximately 100 trees removed from the stand in various size-classes. Among the species removed were *Carya ovata* (Mill.) K. Koch for firewood, *Quercus alba* L., *Q. velutina* Lam., *Q. rubra* L., *Liriodendron tulipifera* L., and *Magnolia acuminata* L. for construction and stave bolts. This forest has been surrounded by farmland since the early 1900's and has experienced gullying along intermittent stream channels and windstorm

damage (Weaver & Ashby 1971; Shotola, *et al.* 1992). A timber harvest occurred in November 1995, primarily due to an increase of *Acer saccharum* and *Fagus grandifolia* in the understory and the mortality of many oak and hickory overstory trees. Future management of this forest will include re-planting of oaks and hickories, removal of the *Acer* and *Fagus* understory, and construction of water bars to control erosion.

METHODS

Thirty trips were made to Weaver's Woods from 1 April to 15 November 1995 to collect voucher specimens, accumulate abundance and habitat information for each taxon, and delineate habitats. The entire forest was systematically searched approximately once each week during the growing season with special attention given to areas with high species richness. Voucher specimens were deposited at the Illinois Natural History Survey Herbarium (ILLS). Identifications, along with criteria for native and non-native taxa designation and plant duration, were made using Fernald (1950), Radford, *et al.* (1968), Mohlenbrock (1986), Gleason & Cronquist (1991), and Smith (1994). Nomenclature follows Mohlenbrock (1986).

Photosynthetic pathway (C_3/C_4) for each taxon collected at Weaver's Woods was determined using Downtown (1975), Raghavendra & Das (1978), Waller & Lewis (1979), Ueno, *et al.* (1989), and Baskin, *et al.* (1995) (Table 1). Plant duration (annual/perennial) was determined from taxonomic sources listed above. Annual designation also included those taxa (e.g., *Lactuca*) that have a biennial life cycle. Graminoids included Cyperaceae, Juncaceae, and Poaceae. Forb included non-woody and non-graminoid flowering plants. Woody plants included trees, shrubs, and lianas, while ferns and fern allies were listed as pteridophytes. Woody plants and pteridophytes were assumed to have C_3 photosynthetic pathways (Baskin, *et al.* 1995).

Plant life form (Raunkiaer 1934) was determined for each taxon using information in Ennis (1928), MacDonald (1937), Oosting (1942), Hansen (1952), Gibson (1961), and Baskin, *et al.* (1995).

Abundance ratings (Appendix 1) were defined to give a relative quantification to field observations and were modified from Murrell & Wofford (1987), Lortie, *et al.* (1991), Looney, *et al.* (1993), and Joyner & Chester (1994). Abundance rating refers to abundance of a taxon within habitats where it is known to occur. When a taxon occurs in more than one habitat, the first listed habitat (optimum) was used to calculate species richness by habitat type (Table 2). Abundance rating were: 1) abundant, species dominant in listed habitat(s); 2) frequent, species co-dominant or in large numbers in listed habitat(s); 3) occasional, species in moderate numbers in listed habitat(s); 4) infrequent, species in small numbers or few individuals in listed habitat(s); and 5) rare, species known from only one individual, a few individuals in a restricted habitat, or from one population.

Habitats for dry-mesic and mesic upland forest were designated using the system of White & Madany (1978). Canopy gap and forest edge habitats, not recognized by

White & Madany (1978), were recognized in this study based upon floristic composition and canopy structure.

RESULTS AND DISCUSSION

Based upon 230 collections made during this study, the known vascular flora of Weaver's Woods consisted of 215 species and subspecific taxa in 77 families and 155 genera. No state threatened or endangered taxa were identified. Twenty-four taxa (11.2%) were non-native to the study site (Table 3). Families with greatest representation by individual taxa were Asteraceae (25 taxa), Poaceae (19), Cyperaceae (10), Liliaceae (7), Rosaceae (7), Fabaceae (6), and Juglandaceae (6). The largest genus was *Carex* (10 taxa), followed by *Carya* (5), *Polygonum*, *Quercus*, and *Smilax* (4 taxa each). Genera with three taxa included *Acer*, *Botrychium*, *Desmodium*, *Dichanthelium*, *Elymus*, *Galium*, and *Ranunculus*.

Weaver's Woods was dominated by C_3 perennial forbs (71 taxa/33.2%), C_3 woody plants (64/29.8%), and C_3 annual forbs (41/19.2%). There were 112 forb taxa (52.1%), 64 woody taxa (29.8%), 30 graminoid taxa (14.0%), and 9 pteridophytes (4.2%) (Table 1). The totals of 64 woody and 151 herbaceous taxa were well above the criteria established for mesic old-growth forests in the central hardwood region (Parker 1989). Of forb and graminoid taxa, 47 (33.1%) were annual and 95 (66.9%) were perennial. Of the 47 annual taxa, six (12.3%) were considered to be biennial: *Campanula americana* L., *Cirsium discolor* (Muhl.) Spreng., *Hackelia virginiana* (L.) I.M. Johnston, *Lactuca canadensis* L., *L. floridana* (L.) Gaertn., and *Verbascum thapsus* L. The predominant photosynthetic pathway for all vascular taxa was C_3 (96.2%). Only eight taxa (3.8%), all in the Poaceae, were considered to have the C_4 photosynthetic pathway (Table 1). These eight taxa were confined to canopy gaps with high solar insolation and temperature. Several studies from the eastern United States in granitic and limestone outcrops (Philips 1982; Baskin, *et al*, 1995), and bottomland forests and swamps (Basinger, *et al.* 1996) also indicate that the C_3 photosynthetic pathway was most common.

Life forms of the 214 taxa identified from Weaver's Woods were as follows: hemicryptophytes (76 taxa/35.3%), phanaerophytes (62/28.8%), therophytes (41/19.1%), cryptophytes (35/16.3%), and chamaephytes (1/0.5%). Six biennial taxa and two perennial *Rubus* taxa were considered as hemicryptophytes, although they were considered as annual and woody taxa respectively, in plant duration. Studies in the eastern United States from localized granite and limestone outcrops (Philips 1982; Baskin, *et al.* 1995), regional areas (Oosting 1942), and statewide floras (MacDonald 1937; Hansen 1952; Gibson 1961) all note that the most prevalent life form is the hemicryptophyte.

Although habitats at Weaver's Woods were dominated by woody vegetation, the proportion of herbaceous growth forms within each habitat did vary. C_3 perennial forbs, C_3 perennial graminoids, and pteridophytes were frequent components of dry-mesic forest. C_3 annual forbs were frequent along intermittent streams and alluvial terraces in mesic upland forest, while C_3 annual forbs and C_4 graminoids were frequent in canopy gaps and along the forest edge (Table 1).

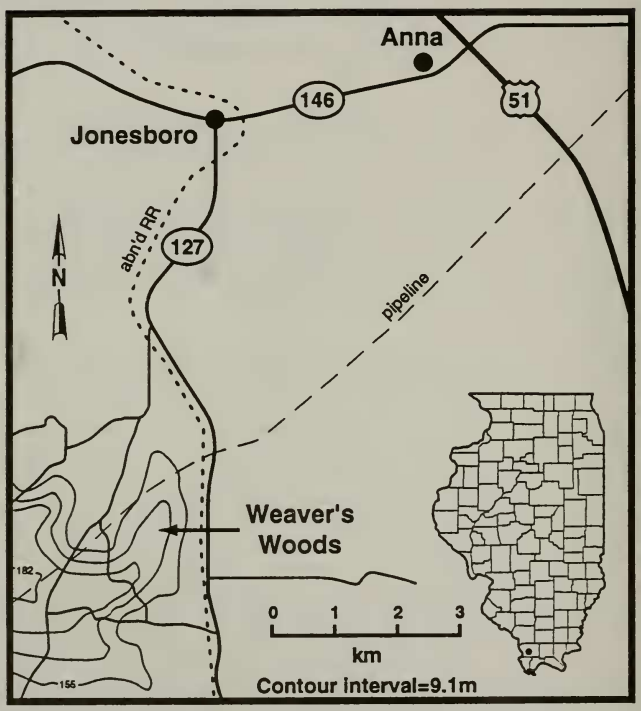

Figure 1. Location of Weaver's Woods, approximately 9 km south of Anna, Union County, Illinois.

Table 1. Distribution of growth forms and plant duration at Weaver's Woods, Union County, Illinois, 1995 survey (Annual includes those taxa with biennial duration).

GROWTH FORM	ANNUAL	PERENNIAL
C_3 GRAMINOID	0	22
C_4 GRAMINOID	6	2
C_3 FORB	41	71
C_3 WOODY		64
C_3 PTERIDOPHYTE		9
TOTAL	47	168

Table 2. Species richness per habitat type at Weaver's Woods, Union County, Illinois, 1995 survey.

RELATIVE ABUNDANCE	HABITAT TYPE				
	DRY-MESIC FOREST	MESIC FOREST	CANOPY GAP	FOREST EDGE	TOTAL
ABUNDANT	6	1	0	0	7(0)
FREQUENT	29	4	1	0	34(0)
OCCASIONAL	18	1	3	2	24(2)
INFREQUENT	32	21	4	10	67(8)
RARE	25	35	13	10	83(14)
TOTALS	110(1)	62(10)	21(4)	22(9)	215(24)

Table 3. Summary of the vascular flora of Weaver's Woods, Union County, Illinois, 1995 survey.

	FAMILIES	GENERA	SPECIES AND LESSER TAXA		
			NATIVE	NON-NATIVE	TOTAL
PTERIDOPHYTA	4	7	9	0	9
CONIFEROPHYTA	1	1	1	0	1
ANTHOPHYTA					
A. MONOCOTYLEDONEAE	10	28	41	8	49
B. DICOTYLEDONEAE	62	119	140	16	156
TOTALS	77	155	191	24	215

Species richness was highest in dry-mesic (110 taxa/51.2%) and mesic upland forest (62/28.8%) habitats and lowest in forest edge (22/10.2%) and canopy gap (21/9.8%) habitats (Table 2). The high species richness values for dry-mesic and mesic upland forest were most likely a function of the area of these habitats, since they occupy approximately 81% and 15% of the site, respectively. Species richness of non-native taxa was highest in mesic forest, primarily in rocky, intermittent stream beds (10 taxa/4.7%), and forest edge (9/4.2%) habitat types, and lowest in the dry-mesic forest (1/0.5%) habitat (Table 2).

Abundance ratings indicate that only seven taxa (3.3%) were abundant and 34 taxa (15.8%) were frequent within their respective habitat optima at Weaver's Woods (Table 2). The majority of taxa (80.9%) were occasional (11.2%), infrequent (31.2%), or rare (38.6%) in abundance within their habitat optimum (Table 2). This may be due to fragmentation (edge effect) and increased canopy shade from *Acer saccharum*, *Asimina triloba* (L.) Dunal, and *Fagus grandifolia* during the growing season which limit habitat and growth of shade intolerant plant species (Shotola, *et al.* 1992). Future study will examine response of the vascular flora to tree harvesting, in particular the potential increase and/or spread of non-native taxa, and changes in the life-form and photosynthetic pathway composition.

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APPENDIX 1

The vascular flora of Weaver's Woods is arranged alphabetically by family, genus, and species. Taxa that are non-native to the study site are preceded by an asterisk (*). After the binomial and authority, a list of habitat types (1 = dry-mesic forest, 2 = mesic forest, 3 = canopy gap, 4 = forest edge) where the taxon occurred most often is given first, followed by an abundance statement (A = abundant, F = frequent, O = occasional, I = infrequent, R = rare), collection number of the first author, life form (Ph = phanaerophyte, H = hemicryptophyte, Cr = cryptophyte, Th = therophyte, Ch = chamaephyte), and photosynthetic pathway.

ACERACEAE

Acer negundo L. 2; R; 10316; Ph; C_3
Acer rubrum L. 2, 1; R; 10317; Ph; C_3
Acer saccharum Marsh. 1, 2, 3, 4; A; 9654; Ph; C_3

ADIANTACEAE

Adiantum pedatum L. 1; R; 9518; Cr; C_3

ANACARDIACEAE

Rhus glabra L. 3; I; 9889; Ph; C_3
Toxicodendron radicans (L.) Kuntze 1, 4, 2, 3; A; 9900; Ph; C_3

ANNONACEAE

Asimina triloba (L.) Dunal 1, 2, 3, 4; A; 10362A; Ph; C_3

APIACEAE

Chaerophyllum procumbens (L.) Crantz 2; I; 9507; Th; C_3
Cryptotaenia canadensis (L.) DC. 1, 2; F; 9645, 9861; H; C_3
Osmorhiza longistylis (Torr.) DC. 1, 2; F; 9515; H; C_3
Sanicula canadensis L. 1, 2; F; 9644, 9860; H; C_3

AQUIFOLIACEAE

Ilex decidua Walt. 1; R; 10255; Ph; C_3

ARACEAE

Arisaema dracontium (L.) Schott 1, 2; O; 9509; Cr; C_3
Arisaema triphyllum (L.) Schott 1, 2; F; 9519; Cr; C_3

ARALIACEAE

Aralia spinosa L. 1, 4; I; 10249; Ph; C_3
Panax quinquefolius L. 1, 2; O; 9514; Cr; C_3

ARISTOLOCHIACEAE

Aristolochia serpentaria L. 1; I; 10241; Cr; C_3

ASCLEPIADACEAE

Cynanchum laeve (Michx.) Pers. 4, 3; R; 10307; Cr; C_3
Matelea gonocarpa (Walt.) Shinners 1; R; 10360; H; C_3

ASPLENIACEAE

Asplenium platyneuron (L.) Oakes 1; I; 9481; H; C_3
Cystopteris protrusa (Weatherby) Blasd. 1; O; 10361; Cr; C_3
Polystichum acrostichoides (Michx.) Schott 1, 2; I; 9497; H; C_3

ASTERACEAE

Ambrosia artemisiifolia L. 2, 3; R; 10294; Th; C_3
Ambrosia trifida L. 4, 2, 3, 1; I; 10240; Th; C_3
Aster lateriflorus (L.) Britt. 2, 4; I; 10331; H; C_3
Aster simplex Willd. 2; R; 10362; H; C_3
Bidens bipinnata L. 3; R; 10242; Th; C_3
Bidens frondosa L. 3; R; 10333; Th; C_3
Cirsium discolor (Muhl.) Spreng. 3, 4; R; 10296; H; C_3
Conyza canadensis (L.) Cronq. 3, 4; R; 10246; Th; C_3
Elephantopus carolinianus Raeusch. 3, 4; R; 10239; H; C_3
Erechtites hieracifolia (L.) Raf. 3, 2, 1; O; 10247; Th; C_3
Erigeron annuus (L.) Pers. 2, 1; I; 9668; Th; C_3
Erigeron philadelphicus L. 2, 3; I; 9492; H; C_3
Eupatorium rugosum Houtt. 1, 4, 3, 2; F; 10363; H; C_3
Eupatorium serotinum Michx. 3, 4; I; 10250; H; C_3
Gnaphalium purpureum L. 2; R; 10345; Th; C_3
Helianthus divaricatus L. 4; R; 10251; Cr; C_3
Lactuca canadensis L. 1, 4; R; 10295; H; C_3
Lactuca floridana (L.) Gaertn. 1, 3, 4; I; 10252; H; C_3
Prenanthes altissima L. var. *cinnamomea* Fern. 1; I; 10327; H; C_3
Senecio glabellus Poir. 2; I; 9491; Th; C_3
Solidago caesia L. 1, 2; R; 10329; H; C_3

Solidago canadensis L. 4, 3; I; 10291; H; C_3
**Taraxacum officinale* Weber 2; R; 10364; H; C_3
Vernonia gigantea (Walt.) Trel. 2, 4; R; 10305; H; C_3
Xanthium strumarium L. var. *canadensis* (Mill.) Torr. & Gray 3, 4; R; 10330; Th; C_3

BALSAMINACEAE

Impatiens capensis Meerb. 2, 1, 3; F; 9862; Th; C_3

BERBERIDACEAE

Podophyllum peltatum L. 1; A; 9864; Cr; C_3

BIGNONIACEAE

Campsis radicans (L.) Seem. 4, 1; R; 9897; Ph; C_3

BORAGINACEAE

Cynoglossum virginianum L. 1, 2; I; 9479; H; C_3
Hackelia virginiana (L.) I.M. Johnston 1, 3; O; 10238; H; C_3
Myosotis macrosperma Engelm. 2; R; 10365; Th; C_3

BRASSICACEAE

**Cardamine hirsuta* L. 2, 1, 3; I; 9489; Th; C_3
Dentaria laciniata Muhl. 1, 2; F; 9484; Cr; C_3
**Thlaspi arvense* L. 2; R; 9493; Th; C_3

CAESALPINIACEAE

Cercis canadensis L. 1, 4; R; 10341; Ph; C_3
Gleditsia triacanthos L. 2, 4, 3; I; 9867; Ph; C_3

CALLITRICHACEAE

Callitriche terrestris Raf. 2; R; 10366; Th; C_3

CAMPANULACEAE

Campanula americana L. 2, 1; I; 10236; H; C_3
Lobelia inflata L. 1, 2; I; 9881, 10292; Th; C_3
Lobelia siphilitica L. 2; I; 10230; H; C_3

CAPRIFOLIACEAE

**Lonicera japonica* Thunb. 4, 2, 1; O; 9871; Ph; C_3
**Lonicera maackii* (Rupr.) Maxim. 4, 3,1; I; 9659; Ph; C_3
Sambucus canadensis L. 1, 3, 2; F; 9868; Ph; C_3
Viburnum rufidulum Raf. 1; I; 9508; Ph; C_3

CARYOPHYLLACEAE

**Stellaria media* (L.) Vill. 2; I; 10342; Th; C_3

CELASTRACEAE

Celastrus scandens L. 4, 1; I; 9500; Ph; C_3
Euonymus atropurpurea Jacq 1, 2, 4; F; 9504, 10248; Ph; C_3
**Euonymus fortunei* (Turcz.) Hand.-Mazz. 4, 1; I; 9503; Ph; C_3

CHENOPODIACEAE
Chenopodium album L. 1, 3, 4; I; 10318, 10337; Th; C_3

COMMELINACEAE
**Commelina communis* L. 2; R; 9888; Th; C_3

CONVOLVULACEAE
**Ipomoea hederacea* (L.) Jacq. 4, 3; R; 10323; Th; C_3

CORNACEAE
Cornus drummondii C.A. Mey. 1, 4; I; 9873; Ph; C_3
Cornus florida L. 1, 4; I; 9896; Ph; C_3

CORYLACEAE
Carpinus caroliniana Walt. 1, 2; I; 9872; Ph; C_3
Ostrya virginiana (Mill.) K. Koch 1, 2; O; 10299; Ph; C_3

CUPRESSACEAE
Juniperus virginiana L. 1; R; 9648; Ph; C_3

CYPERACEAE
Carex amphibola Steud. 1, 2; F; 9473, 9513; H; C_3
Carex artitecta Mack. 1; I; 9501; H; C_3
Carex blanda Dewey 1, 2; F; 9506; H; C_3
Carex cephalophora Willd. 1; R; 9477; H; C_3
Carex digitalis Willd. 1; I; 9494; H; C_3
Carex hirsutella Mack. 1, 4; R; 9874; Cr; C_3
Carex hirtifolia Mack. 1; R; 9512; Cr; C_3
Carex jamesii Schwein. 1, 2; F; 9496; H; C_3
Carex laxiflora Lam. 1; R; 9476, 9529; H; C_3
Carex rosea Willd. 1, 2; R; 9498, 9524; H; C_3

DIOSCOREACEAE
Dioscorea quaternata (Walt.) J.F. Gmelin 1, 2, 4; I; 9520; Cr; C_3

EBENACEAE
Diospyros virginiana L. 1, 4, 3, 2; I; 10293; Ph; C_3

ELAEAGNACEAE
**Elaeagnus umbellata* Thunb. 4; R; 9895; Ph; C_3

EUPHORBIACEAE
Acalypha rhomboidea Raf. 3, 2; R; 10244; Th; C_3
Acalypha virginica L. 3, 1; I; 10243, 10382; Th; C_3

FABACEAE
Amphicarpa bracteata (L.) Fern. 1, 2; I; 9878, 10301; Th; C_3
Desmodium canescens (L.) DC. 4; R; 10319; H; C_3
Desmodium glabellum (Michx.) DC. 1, 4; R; 10302, 10335; H; C_3
Desmodium paniculatum (L.) DC. 1, 4; R; 10320; H; C_3
**Robinia pseudo-acacia* L. 4, 1; I; 10328; Ph; C_3

**Trifolium repens* L. 2; R; 10367; H; C_3

FAGACEAE
Fagus grandifolia Ehrh. var. *caroliniana* (Loud.) Fern. & Rehd. 1, 2; F; 9649; Ph; C_3
Quercus alba L. 1, 2, 4; F; 9639; Ph; C_3
Quercus prinoides Willd. var. *acuminata* (Michx.) Gl. 2, 1; R; 9658; Ph; C_3
Quercus rubra L. 1, 4; F; 9647; Ph; C_3
Quercus velutina Lam. 1, 4; F; 9646; Ph; C_3

FUMARIACEAE
Corydalis flavula (Raf.) DC. 1, 3, 2; F; 9475; Th; C_3

HAMAMELIDACEAE
Liquidambar styraciflua L. 2, 1, 3, 4; I; 9667; Ph; C_3

HYDRANGEACEAE
Hydrangea arborescens L. 1, 2; R; 9876; Ph; C_3

HYPERICACEAE
Hypericum punctatum Lam. 1; R; 10322B; H; C_3

IRIDACEAE
Sisyrinchium angustifolium Mill. 2; R; 9886; H; C_3

JUGLANDACEAE
Carya cordiformis (Wang.) K. Koch 1, 2; I; 9663; Ph; C_3
Carya glabra (Mill.) Sweet 1, 2, 4; F; 9655; Ph; C_3
Carya ovalis (Wang.) Sarg. 1, 2, 4; F; 9656; Ph; C_3
Carya ovata (Mill.) K. Koch 1, 2, 4; F; 9641; Ph; C_3
Carya tomentosa (Poir.) Nutt. 1, 4; R; 10257; Ph; C_3
Juglans nigra L. 1, 2, 4; I; 9653; Ph; C_3

JUNCACEAE
Juncus tenuis Willd. 2, 1; I; 9885; H; C_3

LAMIACEAE
**Perilla frutescens* (L.) Britt. 2, 3; O; 10325; Th; C_3
Prunella vulgaris L. var. *elongata* Benth. 2; I; 10231; H; C_3
Teucrium canadense L. var. *virginicum* (L.) Eat. 4; I; 9866; H; C_3

LAURACEAE
Sassafras albidum (Nutt.) Nees 1, 4, 3, 2; O; 9643; Ph; C_3

LILIACEAE
Allium canadense L. 2; R; 9480; Cr; C_3
**Allium vineale* L. 1, 4; R; 9522; Cr; C_3
**Ornithogalum umbellatum* L. 4, 1; I; 10368; Cr; C_3
Polygonatum biflorum (Walt.) Ell. 1; R; 9517; Cr; C_3
Smilacina racemosa (L.) Desf. 1, 2; I; 9516; Cr; C_3
Trillium recurvatum Beck 1; F; 9488; Cr; C_3
Uvularia grandiflora Sm. 1; I; 9526; Cr; C_3

MAGNOLIACEAE

Liriodendron tulipifera L. 4, 1, 3; O; 9642; Ph; C_3
Magnolia acuminata L. 1, 2; I; 9499; Ph; C_3

MENISPERMACEAE

Cocculus carolinus (L.) DC. 1; R; 10369; Ph; C_3
Menispermum canadense L. 1, 4, 2; O; 9521; Ph; C_3

MORACEAE

**Morus alba* L. 4; R; 9904; Ph; C_3
Morus rubra L. 2, 1, 4, 3; F; 9482; Ph; C_3

NYSSACEAE

Nyssa sylvatica Marsh. 1, 4, 2, 3; O; 9666; Ph; C_3

OLEACEAE

Fraxinus americana L. 1, 4, 2, 3; F; 9661; Ph; C_3

ONAGRACEAE

Circaea lutetiana Aschers. & Magnus subsp. *canadensis* (L.) Aschers. & Magnus 1, 3, 2; F; 9859; Cr; C_3

OPHIOGLOSSACEAE

Botrychium dissectum Spreng. var. *dissectum* 2; R; 10304; Cr; C_3
Botrychium dissectum Spreng. var. *obliquum* (Muhl.) Clute 2, 1; I; 10235; Cr; C_3
Botrychium virginianum (L.) Sw. 1, 2; I; 9485; Cr; C_3
Ophioglossum vulgatum L. var. *pycnostichum* Fern. 2; R; 9486; Cr; C_3

ORCHIDACEAE

Aplectrum hyemale (Willd.) Nutt. 1, 2; F; 9528; Cr; C_3
Corallorhiza wisteriana Conrad 1; R; 9474; Cr; C_3
Tipularia discolor (Pursh) Nutt. 2; R; 9527; Cr; C_3

OXALIDACEAE

Oxalis stricta L. 1, 2; I; 9875; H; C_3

PASSIFLORACEAE

Passiflora lutea L. var. *glabriflora* Fern. 3, 1, 4; I; 9523, 9893; H; C_3

PHRYMACEAE

Phryma leptostachya L. 1, 2, 3; F; 9863; H; C_3

PHYTOLACCACEAE

Phytolacca americana L. 3, 1, 4, 2; F; 9870; Cr; C_3

PLANTAGINACEAE

Plantago rugelii Dcne. 2; R; 9879, 10381; H; C_3

PLATANACEAE

Platanus occidentalis L. 2, 4; I; 9650; Ph; C_3

POACEAE

Agrostis perennans (Walt.) Tuckerm. 2, 1; R; 10245, 10343; H; C_3
Bromus pubescens Muhl. 1; R; 10370; H; C_3
Dichanthelium acuminatum (Sw.) Gould & Clark var. *fasciculatum* (Torr.) Freckm. 2; R; 10297; H; C_3
Dichanthelium boscii (Poir.) Gould & Clark 2; R; 9877; H; C_3
Dichanthelium clandestinum (L.) Gould 2; I; 10324; H; C_3
**Digitaria ischaemum* (Schreb.) Muhl. 2; R; 10339; Th; C_4
**Digitaria sanguinalis* (L.) Scop. 3; R; 10322; Th; C_4
Echinochloa muricata (Beauv.) Fern. 2; R; 10338; Th; C_4
Elymus hystrix L. 2; R; 9884; H; C_3
Elymus villosus Muhl. 2; R; 9665; H; C_3
Elymus virginicus L. 1, 2, 4; O; 9887; H; C_3
Leersia virginica Willd. 2, 1, 3; F; 10232; H; C_3
Muhlenbergia sobolifera (Muhl.) Trin. 2; R; 10371; H; C_4
Panicum dichotomiflorum L. 2; R; 10340; Th; C_4
Poa sylvestris Gray 1, 4; R; 10372; H; C_3
**Setaria faberi* Herrm. 3; R; 10254; Th; C_4
**Setaria viridis* (L.) Beauv. var. *major* (Gaudin) Pospichal. 3; R; 10334; Th; C_4
**Sorghum halepense* (L.) Pers. 3, 4; R; 10373; Cr; C_4
Sphenopholis obtusata (Michx.) Scribn. 1; R; 9478; H; C_3

POLEMONIACEAE

Phlox divaricata L. subsp. *laphamii* (Wood) Wherry 1, 2; O; 9505; Ch; C_3

POLYGONACEAE

**Polygonum cespitosum* Blume var. *longisetum* (DeBruyn) Stewart 2; I; 10298; Th; C_3
Polygonum punctatum Ell. 2, 3; I; 9903, 10336; Th; C_3
Polygonum scandens L. 1, 3, 4; O; 10326; H; C_3
Polygonum virginianum L. 1, 2, 3; F; 10237; H; C_3

PORTULACACEAE

Claytonia virginica L. 1, 2; F; 10374; Cr; C_3

PRIMULACEAE

Samolus valerandii L. 2; R; 10303; H; C_3

RANUNCULACEAE

Clematis virginiana L. 3; R; 10321; H; C_3
Hydrastis canadensis L. 1, 2; O; 9664; Cr; C_3
Ranunculus abortivus L. 2; R; 9495; H; C_3
Ranunculus micranthus Nutt. 2; R; 9487; H; C_3
Ranunculus recurvatus Poir. 1, 2; I; 9525; H; C_3

ROSACEAE

Agrimonia parviflora Ait. 2; R; 10300; H; C_3
Agrimonia rostellata Wallr. 1, 2; I; 9898; H; C_3
Geum canadense Jacq. 1, 2, 4; F; 9883; H; C_3
Prunus serotina Ehrh. 1, 4, 3, 2; F; 9652; Ph; C_3

**Rosa multiflora* Thunb. 4, 2; I; 9894; Ph; C_3
Rubus allegheniensis Porter 4; I; 10375; H; C_3
Rubus occidentalis L. 4; R; 10376; H; C_3

RUBIACEAE
Galium aparine L. 1, 3, 2, 4; F; 10377; Th; C_3
Galium circaezans Michx. 1, 2; O; 9640; H; C_3
Galium triflorum Michx. 1, 2; O; 9882; H; C_3

SCROPHULARIACEAE
Gratiola neglecta Torr. 2; R; 10378; Th; C_3
Scrophularia marilandica L. 1, 3, 4; I; 10233; H; C_3
**Verbascum thapsus* L. 2; R; 10344; H; C_3
Veronica peregrina L. 2; R; 9490; Th; C_3

SMILACACEAE
Smilax glauca Walt. 1, 3; I; 9483; Ph; C_3
Smilax hispida Muhl. 1, 3, 2, 4; O; 9502, 10380; Ph; C_3
Smilax pulverulenta Michx. 1; R; 9472; H; C_3
Smilax rotundifolia L. 1, 3, 4; O; 9892; Ph; C_3

SOLANACEAE
Physalis heterophylla Nees 3; R; 9869; Cr; C_3
Physalis pruinosa L. 3; O; 10253; Th; C_3
Solanum ptycanthum Dunal 3, 1; O; 10256; Th; C_3

THELYPTERIDACEAE
Phegopteris hexagonoptera (Michx.) Fee 1, 2; I; 9510; Cr; C_3

ULMACEAE
Celtis laevigata Willd. 2, 1, 3, 4; I; 9657; Ph; C_3
Celtis occidentalis L. 1, 2, 3, 4; I; 9651; Ph; C_3
Ulmus americana L. 2, 1, 3; I; 9662; Ph; C_3
Ulmus rubra Muhl. 1, 2, 3, 4; A; 9902; Ph; C_3

URTICACEAE
Boehmeria cylindrica (L.) Sw. 2, 1, 3; I; 9880; Cr; C_3
Parietaria pensylvanica Muhl. 1, 2, 3; I; 9511; Th; C_3
Pilea pumila (L.) Gray 2, 3, 1; A; 10234; Th; C_3

VERBENACEAE
Verbena urticifolia L. 4; R; 9899; H; C_3

VIOLACEAE
Viola sororia Willd. 2, 1, 3; F; 10379; H; C_3

VITACEAE
Ampelopsis cordata Michx. 4; R; 10306; Ph; C_3
Parthenocissus quinquefolia (L.) Planchon 1, 4, 3, 2; A; 9901; Ph; C_3
Vitis aestivalis Michx. 1, 3, 4, 2; O; 9891; Ph; C_3
Vitis vulpina L. 1, 3, 4, 2; O; 9890; Ph; C_3